Strengthening Oral Language Skills in Mathematics for English Language Learners Through Desmos® Technology

https://doi.org/10.3991/ijet.v12i05.6947

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Abstract—A major focus of teaching English Language Learners (ELL) in mathematics classrooms is to provide multiple opportunities for students to use authentic language. Barrier games offer ELLs a balance between productive (speaking, writing) and receptive (listening, reading) language. In a barrier game, students work in pairs to complete an information gap activity where learners are missing the information they need to complete a task and need to talk to each other to find it. With Desmos®' *Polygraph* program, students are provided online tools for transforming informal language into formal language similar to a Barrier Game. Following a background of barrier games in mathematics, this article will provide a detailed description of *Polygraph* and its potential for *all* students to learn and apply authentic mathematical language.

Keywords—Academic language, referential language, mathematics

1 Introduction

A barrier game is a type of information-gap task. In the classroom, information–gap tasks involve partners consisting of a speaker and a listener and a message to be communicated [1]. A "barrier" is placed between the students so that neither can see what the other is doing. One student describes the elements of a task so that the student on the other side of the barrier can complete the actions. At the end of the game, the barrier is removed and the results are checked for accuracy. Because they cannot see each other, pairs of students engaged in a barrier game cannot use gestures or similar aids for comprehension. They must express themselves using decontextualized language. Practice in using language precisely and in understanding decontextualized language helps students develop skills needed for learning to read and learn mathematics [2].

Barrier type activities encourage oral language experiences, that is, people normally communicate in order to get information they do not possess. More authentic communication is likely to occur in the classroom if students go beyond practice of language forms for their own sake and use their linguistic and communicative resources in order to obtain information. In so doing, they will draw available vocabulary, grammar, and communication strategies to complete a task [3].

2 Benefits of Barrier Games

The following characteristics of barrier games demonstrate the benefits for ALL learners of any content area.

2.1 Active Listening

In Barrier Games, students need to ask for more information or a repeat of instructions if they are not sure what has been said or do not understand the instructions. They are rewarded for good listening skills by succeeding with the task [4].

2.2 Awareness of listener perspective.

Many children with language difficulties assume that the people listening to them understand the context and background of their conversation. They do not appreciate the listener is not seeing everything the way that they do and may not have some of the key information needed to understand what is being said.

2.3 Referencing skills.

English Language Learners often use vague terms such as “it” or “that” without making their referent clear. Referential communication can help children to understand the importance of being specific when giving instructions as the listener is left totally confused if they are not given the right information [6].

2.4 Awareness of communication breakdown.

The child gets clear, immediate feedback when their communication attempt has been unsuccessful. It is useful to discuss why any misunderstandings happened to increase their awareness and help them to learn for future communication. In referential communication, children have the opportunity to practice repairing communication breakdown [7]. Thus, referential communication requires one to choose the best words (semantics), put them in the right order (syntax), and take the perspective of the listener in order to know what the listener needs to hear (pragmatics).

3 The Relationship Between Academic Language, Mathematics, and Desmos®

Research on language that is specific to mathematics instruction for ELLs provides several guidelines for instructional practices for teaching mathematics that are consistent with referential communication and task-based language instruction. Moschovich [8] outlines recommendations for mathematics instruction for ELLs should:

1. Treat language as a resource, not a deficit [9]
2. Address much more than vocabulary and support ELLs' participation in mathematical discussions as they learn English [10].
3. Draw on multiple resources available in classrooms – such as objects, drawings, graphs, and gestures as well as home languages [11].

Consistent with mathematical tasks that go beyond merely memorizing vocabulary and pronunciations is the use of Desmos® *Polygraph* [12]. Unlike graphing calculators, Desmos® is a free, web browser-based graphing utility that is highly intuitive, and can be used to facilitate students' construction of mathematical knowledge in authentic ways (www.desmos.com). One program, created by the Desmos® design team is a series of files entitled, *Polygraph,* which mirrors many of the recommendations for English Language Learners described above.

4 Desmos® *Polygraph*

Polygraph is an online barrier game in which one student has selected a shape or graph. Their partner will then ask questions that will enable the other student to eliminate non- items. Figure 1 demonstrates the question/answer process of identifying quadrilaterals.

Other content available in *Polygraph* activities includes lines, parabolas, hexagons, rational functions, and advanced quadrilaterals. Because students read and write questions throughout the *Polygraph* activity, it is especially appropriate and helpful for English Language Students. A sample "dialogue" demonstrates the powerful tool Polygraph is in the study of lines.

"Is the slope greater than 0?"
"Does the line cross the origin?
"Is the y-intercept greater than 0?"
"Is the slope undefined?

A useful feature of Desmos® is the Teacher Dashboard through which teachers can access student conversations. Figure 2 depicts the teacher dashboard with access to students' questions and responses. Teachers can investigate to what extent students use formal vocabulary.

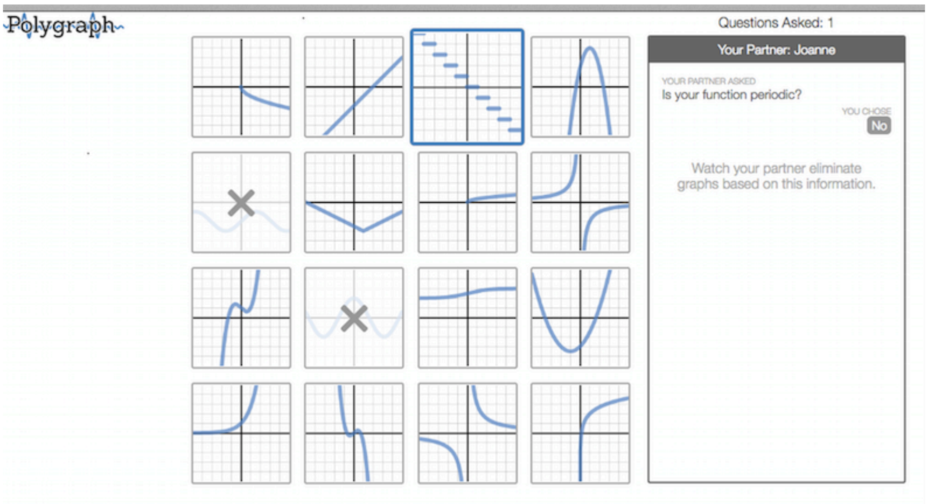

Fig. 1. Desmos® *Polygraph* page with some items eliminated.

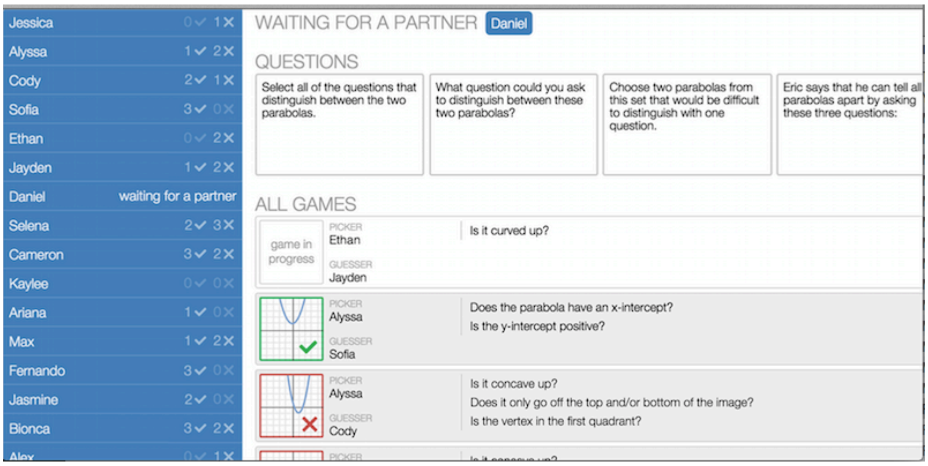

Fig. 2. Desmos® Polygraph's Teacher Dashboard.

Students' knowledge of properties and characteristics of a particular shape or graph can be assessed through examining student responses and questions, teachers can also identify misconceptions and assess student learning. Teachers could play a final round against the class to end the activity while evaluating the nature of students' questions. As an alternative, the dashboard can be used to identify some interesting questions that students asked as they played, and bring these questions to their attention. These might include use of vocabulary words a teacher wants to introduce or examples of students noticing characteristics about the figures or graphs.

5 Conclusion

While some may consider mathematics classrooms a chance for students with limited English proficiency to shine since "mathematics is a universal language," we cannot assume that these students will perform at grade level without receiving specialized instruction in English. Mathematics is, however, demanding and context-specific type of problem-solving in which students explore deeply and explain problem-solving strategies, rather than merely memorizing formulas and algorithms [10]. Argumentation, persuasion, and precision in terminology are the basis of much of mathematics meaning that ELLs require English proficiency as well as target mathematical vocabulary and general academic language. Students may work with open-ended problems, questions with multiple solutions, concepts demanding group participation, and tasks with real-world applications. Through implementing Desmos' *Polygraph*, these standards are addressed with the additional component of a teacher dashboard that enables teachers to monitor problems, assess understanding, and engage in student-to-student interaction, meeting the needs of *all* students.

6 Acknowledgements

This research was supported in part by a grant from the Ohio Department of Higher Education, Teacher Quality Improvement Program Grant # 15-23.

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Article submitted 14 April 2017. Published as resubmitted by the authors 23 May 2017.